Original Article

Limb salvage with open surgical revascularization in acute ischemia due to thrombosed popliteal artery aneurysm

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Abstract

Introduction: Acute ischemia due to thrombosed popliteal artery aneurysm (PAA) is associated with a high risk of limb loss. The aim of this study was to analyze the outcome, in particular the limb salvage rate in patients undergoing urgent open surgery for acute ischemia due to thrombosed PAA.

Methods: Retrospective analysis of consecutive patients undergoing urgent open surgery for acute limb ischemia (Rutherford category ≥ II) due to thrombosed popliteal artery aneurysm between January 2007 and December 2016 at a tertiary referral center.

Results: Fifty-one patients (92% male) with a median age of 75 years (range 46-97) were identified. Twenty patients (39%) presented with category IIa acute limb ischemia, 20(39%) with category IIb, and 11(22%) with category III. Four patients (8%) underwent primary major amputation. Forty-seven (92%) underwent bypass surgery, 43/47(91%) using great saphenous vein. One-vessel runoff was present in 27/47 patients (57%). Thirty-day mortality was 4% (n=2). Four patients needed major amputation within 30 days, resulting in an overall 30-day major amputation rate of 16% (8/51, 95% CI 7.0-28.6). No further major amputations were necessary during a median follow-up of 41 months (range 4-114) resulting in an estimated four-year limb salvage of 84%. One-year primary assisted and secondary bypass patency rate was 90% and 95%, respectively. Estimated four-year primary assisted and secondary patency rate was 82% and 87%, respectively.

Conclusion: Rapid open surgical revascularization in patients with acute limb ischemia due to a thrombosed popliteal artery aneurysm results in good long-term limb salvage rates, especially in Rutherford category IIa and IIb of acute ischemia. Revascularization may be attempted in clinically severe cases not fulfilling all criteria to be classified as

category III. Such patients may in fact be borderline between IIb and III. Despite poor runoff, good bypass patency rates and low rates of claudication can be achieved.

Introduction

Popliteal artery aneurysms (PAA) are relatively rare with a prevalence of approximately 1% in men aged 65–80 years,[1] accounting for more than 80% of all peripheral aneurysms.[2] Acute limb ischemia (ALI) due to aneurysm thrombosis or distal embolization is the most severe complication of a PAA.[3] Revascularization is challenging and usually performed by open surgery, although a complete endovascular approach has been reported.[4] As crural arteries are often occluded, options for complete revascularization of the foot are limited possibly resulting in major amputation. Amputation is associated with worse functional outcome, especially in elderly patients with cardiovascular comorbidities.[5,6] Furthermore, primary amputation offers no cost-benefit compared to bypass surgery when considering the cost of the prosthesis and rehabilitation.[7] Thus, every effort should be taken to achieve limb salvage. The 2017 ESC Guidelines on the management of peripheral artery disease cover ALI, but specific recommendations regarding PAA are lacking.[8] In Rutherford category II urgent revascularization is indicated. For patients with acute Rutherford category III limb ischemia, the current recommendation is amputation. There are contemporary series addressing outcome in ALI due to thrombosed PAA.[9,10] These registry papers may underestimate the amputation rate of thrombosed popliteal artery aneurysms because they either excluded primary amputations or lack adequate follow-up.[9,10] In other articles reporting the open surgical management of PAA, follow-up of patients presenting with acute ischemia is poor as well.[11] The use of preoperative thrombolysis in ALI due PAA is controversial and a significant benefit has not been shown in a recent systematic review.[11] We therefore aim to analyze perioperative as well as long-term outcome of patients undergoing urgent open surgery for ALI due to thrombosed popliteal artery aneurysm, assessing limb salvage and mortality.

Materials and Methods

This study was approved by the local ethics committee (ID 2017-01529). Consecutive patients with Rutherford category IIa, IIb, and III ALI due to thrombosed PAA undergoing urgent surgery between January 2007 and December 2016 were identified and reviewed retrospectively. Patients with category I ischemia were excluded.

Popliteal artery aneurysm was defined as a popliteal artery diameter of ≥ 13 mm and ≥ 1.5 times the diameter of the upstream and downstream segments measured on ultrasound or computed tomography (CT) images. The diagnostic algorithm for ALI and suspected PAA thrombosis included clinical examination and duplex ultrasound. Preoperative CT angiography was performed at the discretion of the treating vascular surgeon to assess the extent of thrombosis and potential target vessels. The revised Rutherford category of acute ischemia[12] was preoperatively assessed by the treating vascular surgeon based on sensorimotor function and Doppler assessment. Of note, category III is named “irreversible” consisting of major tissue loss or permanent nerve damage (inevitables), profound sensory loss (anesthetic), profound muscle weakness (paralysis, rigor), and inaudible arterial and venous Doppler signals. Patients with Rutherford categories IIa, IIb and III were scheduled for urgent (IIa) or emergent (IIb and III) surgery.

Operative technique

Intraoperative angiography was performed to assess target vessels. In case of severe thrombosis without a suitable distal target vessel, all crural vessels were dissected and selective thrombectomy with or without intra-arterial thrombolysis was performed. Depending on the surgeon’s preference, between 100’000 and 500’000 IU Urokinase (Medac GmbH, Wedel, Germany) were delivered into the popliteal or crural arteries. If available, the ipsi- or contralateral great saphenous vein was used as a bypass graft. Arm veins were used as a second choice. If autologous vein material was unavailable, Omniflow® II (LeMaitre Vascular, Burlington, MA, USA) or ePTFE (BARD Peripheral Vascular, Temple, AZ, USA) was used. The standard anticoagulation and anti-platelet regimen consisted of oral anticoagulation with coumadin and acetylsalicylic acid for at least three months and acetylsalicylic acid alone thereafter. In case of severely compromised (1-vessel) runoff, lifelong oral anticoagulation was recommended.

Data collection

Preoperative, intraoperative and postoperative data were retrospectively collected from hospital records. Standard follow-up after bypass surgery included outpatient duplex ultrasound performed at one and three months. After that, patients were followed every 6-12 months in the outpatient clinic with duplex ultrasound performed at the discretion of the treating physician, usually in case of claudication or drop in ankle brachial index (ABI). Follow-up duplex ultrasound reports, ABI measurements, and information on reinterventions for patients who were followed elsewhere were requested from those institutions. Vital status or date of death was confirmed by contacting the patients' primary care physician or extracted from communal databases. For all patients known to be alive, a standardized telephone interview was performed at the beginning of March 2017 assessing for claudication or reinterventions at other institutions. Study end date was defined to be March 6th, 2017. Major amputation was defined as any amputation above the ankle. Patency was defined and assessed according to Rutherford.[12]

Statistical analysis

SPSS Statistics 25.0 (IBM Corp., Armonk, NY, USA) was used for descriptive statistics and GraphPad Prism 7.00 (GraphPad Software Inc., La Jolla California USA) for Kaplan-Meier analysis and 95% confidence intervals using the asymmetrical method. For univariate analysis, we stated proportions, for numerical data mean with standard deviation (SD) or median with range. Patency rates and amputation-free survival were estimated using the Kaplan-Meier method. For follow-up patency rates, only patients with a graft (without in-hospital amputation) were included. Patients known to have died during follow-up were reported separately with the median time to death. For all other patients, follow-up completeness was assessed using the Follow-Up Index.[13]

Results

Patient characteristics and presentation

Fifty-one patients (92% male) with a median age of 75 years (range 46-97) were identified. Comorbidities are listed in Table 1. The median size of the PAA was 33 mm (range 13-80 mm). Six patients (12%) had already undergone open surgery for contralateral PAA and in an additional 25 patients (49%), contralateral PAA was detected at presentation or during follow-up. Twenty patients (39%) presented with Rutherford category IIa acute limb ischemia, 20 patients (39%) with category IIb, and 11 patients (22%) with category III.

Treatment / surgical procedures

Four patients (8%) underwent primary major amputation due to lack of patent outflow vessels on intraoperative angiography images and severe ischemia (Rutherford category IIb in one and category III in three patients). In the remaining 47 patients, revascularization surgery was performed with 44 bypass and 3 interposition grafts. Great saphenous vein (GSV) was used in 43/47 patients (91%). Other grafts used are listed in Table 2. The distal target vessel was the below-knee popliteal artery in 26 patients (55%) and the crural arteries in the remaining patients (Table 2). The surgical approach was medial in 44/47 (94%) and posterior in 3/47 (6%). All bypasses were routed orthotopically. Intraoperative intra-arterial thrombolysis was used as an adjunct in 17 patients (36%) with more severe limb ischemia (3 with category IIa, 7 with category IIb, and 7 with category III; No intraoperative thrombolysis in 17 patients with category IIa, 13 with category IIb, and 4 with category III, p=0.007). Fasciotomy due to compartment syndrome was performed in 15/51 patients (29%). Two patients underwent preoperative local thrombolysis, which is not consistent with our standard approach. In these two patients, the diagnosis of PAA had not been established at admission. Mean length of hospital stay was 14 days (SD 11).

After revascularization, 12 patients (26%) had three-vessel runoff, five patients (11%) had two-vessel runoff, and 27 patients (57%) had one-vessel runoff, as assessed on intraoperative angiography. Three patients (6%) had no patent runoff vessel with bypass outflow to the foot through collaterals only, representing an unsuccessful revascularization (Figure 1). In these three patients, the bypass target was the below-knee popliteal artery in one and the peroneal artery in two patients.

30-day outcomes

Limb salvage. Four patients needed secondary major amputation within 30 days, resulting in an overall 30-day major amputation rate of 16% (8/51; 95% CI 7.0-28.6). Excluding the primary amputations, the 30-day major amputation rate was 9% (4/47). Two of those undergoing secondary major amputation were patients with collateral perfusion only and progressive tissue loss despite a patent bypass. The remaining two patients had one-vessel runoff after initial revascularization; in one the bypass failed after one day and in the other amputation became necessary due to progressive necrosis of the foot while the bypass was patent.

The third patient with collateral only flow to the foot, the bypass remained patent but amputation was recommended due to progression of necrosis. However, the patient denied amputation and died three months later due to septic complications.

Category IIb and III limb ischemia at presentation was significantly associated with 30-day major amputation (8/31 with category ≥ IIb versus 0/20 with category IIa, p=0.02). Overall, of eleven patients presenting with category III ischemia, six patients (55%) underwent primary or secondary amputation and one denied the recommended amputation (mentioned above). In the remaining four patients (36%) with category III ischemia and in 18/20 (90%) with category IIb limb salvage was successful.

Mortality and morbidity. Two patients died within 30 days of surgery, resulting in a 30-day mortality of 4%. One patient died from congestive heart failure due to severe aortic stenosis after successful limb revascularization and one patient died due to multi-organ failure after denying surgery for complicated diverticulitis after primary amputation. Non-fatal in-hospital complications included surgical site hematomas (5), delirium (3), and surgical site bleeding needing reintervention (1), false aneurysm (1), muscle necrosis of the anterior tibial muscle (1), wound infection (1) and pneumonia (1), respectively. No patient experienced acute renal failure requiring hemodialysis.

Follow-up

Seventeen patients died during follow-up after a median of 14 months (range 0-93 months, IQR 42 months). Thirty-two patients were alive at the study end date (March 6th, 2017) with a median follow-up of 41 months (range 4-114 months) and a Follow-up Index of 0.99.

During follow-up, no further major amputations were necessary, resulting in an estimated four-year limb salvage of 84%. Excluding primary amputations, the estimated four-year limb salvage was 91%. Of 32 patients alive at the end of follow-up, 28 were free of major amputation and estimated four-year amputation-free survival was 52% (Figure 2). Two minor amputations were performed two and four years after initial revascularization.

Of 28 amputation-free survivors, one patient reported claudication after 500 meters (Fontaine classification IIa) at the end of follow-up while all other patients were free of claudication. The four patients with limb salvage in category III ischemia were ambulating without complains after revascularization but three died during follow-up after a median of 1.9 years (median age at presentation 89 years); one was alive and free of claudication at the study end date (3.5 years after revascularization).

Graft patency. Estimated 1-year primary assisted and secondary patency rate was 90% and 95%, respectively. Estimated 4-year primary assisted and secondary patency rate was 82% and 87%, respectively (Figure 3).

Re-interventions. Three re-interventions were performed for primary assisted patency: an anastomotic stenosis was treated with a stent in two patients and with an open patch plasty in one patient. Seven patients had bypass occlusion after a median of 36 months (range 0-97) after initial revascularization. In four patients, a bypass thrombectomy was performed. In three of those, a focal stenosis was identified as the cause of bypass occlusion and was treated with patch plasty. Three patients underwent a redo bypass procedure after failed bypass salvage and of these, two underwent a second redo bypass procedure and additional endovascular interventions due to repeated bypass failure.

Discussion

In this single-center retrospective series, we report the outcome of 51 patients with acute limb ischemia due to a thrombosed popliteal aneurysm. Revascularization in this setting remains a surgical challenge since runoff is usually poor and patients may be admitted with considerable time delay. Patients with popliteal artery aneurysms may have multiple silent and time-shifted thromboembolic events before presenting with acute ischemia due to complete aneurysm thrombosis.[14,15] This results in very poor outflow complicating revascularization. In our series, 57% of the patients had one-vessel runoff, and 6% had no patent vessel in the lower leg. Similarly, Lilly and colleagues described decades ago that arterial anatomy below popliteal aneurysms is distinctly abnormal in 90% of the cases with 86% of patients with severe ischemia having only single-vessel runoff.[15]

Thirty-day major amputation rate in our series was 16% (95% CI 7.0-28.6) with four patients undergoing primary amputation and four patients undergoing secondary amputation after attempted revascularization. As no further major amputations were necessary during follow-up, four-year estimated limb salvage rate was 84%. A multicentric Italian study from 2013 reported a two-year limb salvage rate of ALI due to PAA treated surgically of 81.5% (41 patients).[16] Similarly, a systematic review by Kropman et al. reported a five-year limb salvage rate of 74%.[17] A Swedvasc report showed a similar one year amputation rate of 13.4% (including primary amputation), but the follow up at one year was only 87% and the patient cohort was markedly different (13.2% category I patients).[9]

A Vascunet report with data from eight countries, excluding primary amputations, showed a discharge / 30-day amputation rate of 6.5%.[10] However, category of ischemia is not reported. Excluding primary amputations in our series, the one-year amputation rate was 9%.

Estimated four-year primary assisted and secondary patency rates in our series were 82% and 87% respectively. This is in line with Kropman's findings of a five-year secondary patency of 80%.[17] In our series 96% of patients without major amputation denied any claudication symptoms at follow-up, which is also satisfactory, considering the high prevalence of outflow vessel obstruction in these patients.

Clinical assessment and categorization according to Rutherford et al. is crucial when reporting acute limb ischemia. Eleven patients were preoperatively classified as category III. This would actually deem their ischemia irreversible leading to amputation.[8,12] As four patients were salvageable in our series we must, retrospectively, assume that these cases were initially misclassified and did not show all the characteristics described by Rutherford et al. and therefore were severe category IIb patients. Only the postoperative course may have definitely showed that these cases were only mimicking category III, and were therefore salvageable. However, if no runoff can be achieved intraoperatively by means of thrombectomy and thrombolysis, placement of a bypass seems not advisable.

Preoperative thrombolysis has extensively been discussed for ALI due to thrombosed PAA.[18] A recent systematic review could not show significant reduction of amputations after preoperative thrombolysis. Five-year primary patency rates, secondary patency and limb salvage rates were not different after thrombolysis when compared to patients who did not undergo thrombolysis.[17] Many open surgical series included in this review had low patient numbers and acute ischemia was classified only in 122 of 895 patients.[17] In other series investigating this issue, data on the severity of ischemia is lacking.[3] Neurologic deficits (Rutherford category IIb and III) are well-known indications for emergent revascularization.[12] Preoperative thrombolysis may only lead to a better outcome in patients with less severe ischemia who per se have better outcomes regarding limb salvage. We only included patients with limb-threatening ischemia (Rutherford category ≥ II) in our series. These patients should be treated immediately because of the considerable threat of permanent neuromuscular and tissue damage.[8] Preoperative thrombolysis may lead to a delay in open surgical revascularization.[12] Our data does not add knowledge to the topic of preoperative thrombolyis, since it was only performed in two cases.

Open bypass surgery is the standard treatment for ALI due to thrombosed PAA at our institution. A complete endovascular approach has been reported in the literature. The largest series by Fargion and colleagues included six patients.[4] One patient died shortly after early stent thrombosis and major amputation. The remaining five patients showed a primary patency rate of 60% and a secondary patency rate of 80% after a mean follow-up of 28.6 months. The authors state that this approach is an alternative in selected high-risk patients with specific anatomic requirements, but should not replace GSV bypass as the gold standard.[4]

Another important issue is the association of PAA with other aneurysms, especially contralateral PAA or AAA.[11] Sixty-one percent of patients in our series had contralateral PAA. Six patients had already undergone open surgery for contralateral PAA when presenting with acute limb ischemia due to PAA thrombosis on the other side. Median time from previous PAA surgery to contralateral PAA thrombosis was nine years. This emphasizes the importance of life-long follow-up in these patients, not only to assess bypass patency after PAA repair but for surveillance of aneurysmal disease of the contralateral leg and other associated aneurysms. In an elective setting, PAA can be treated with a low morbidity and mortality and excellent long-term outcomes which are far superior to the results in acute ischemia.[11,19] Therefore, we aim to search for PAA in patients with known aneurysms at other sites and operate them electively at a diameter of 20mm.

Limitations. As this is a retrospective single-center study, certain factors may limit the generalizability of the study results. The limited number of patients is reflected by the broad 95% CI in our results. A future large multicentric collaboration could allow for analyses of subgroups to provide more insight concerning the best treatment option for each patient. The category of acute ischemia was documented by the treating vascular surgeon. We assume misclassification for some category III patients, since they were not all amputated. Because this is a retrospective analysis we cannot perform a detailed clinical re-assessment of these cases and had to rely on the clinician's evaluation provided back then. However, publications in this field suffer from this particular bias as well, e.g. some do not report the category of ischemia of the patients included.

There is no comparator group, since all patients were treated by open surgery. The selection of graft material, surgical technique, the use of thrombolysis and the anticoagulation and anti-platelet regimen were at the discretion of the vascular surgeon who operated and therefore not standardized. Although regular follow-up visits in our outpatient clinic were documented in most patients, some were followed at other institutions and therefore clinical and ultrasound follow-up was not standardized. Thus, asymptomatic bypass occlusion might not have been detected in some patients. Causes of death are not known in most of the diseased patients. Furthermore, over the span of ten years substantial improvements in interdisciplinary treatment have been achieved. This might have led to less time to intervention and hence higher limb salvage rates. Due to the small study population, we did not analyze trends over time. The time from symptom onset until revascularization is an important issue in ALI. Most of the patients had gradually worsening symptoms and were not able to report a precise time of symptom onset. A strength of the present study is the defined study end date with almost complete follow-up (Follow-Up Index 0.99) and standardized telephone interviews with all surviving patients at the end of follow-up.

Conclusion. Rapid open surgical revascularization in patients with acute limb ischemia due to thrombosed popliteal artery aneurysm results in good long-term limb salvage rates in our series, especially in Rutherford category IIa and IIb of acute ischemia. Revascularization may be attempted in clinically severe cases not fulfilling all criteria to be classified as category III. Such patients may in fact be borderline between IIb and III. Despite poor runoff, good bypass patency rates and low rates of claudication can be achieved.

What this study adds to the current evidence

This study represents a single-center series of open surgical management of acute presentations of thrombosed popliteal artery aneurysm. It stands out from other contemporary reports due to inclusion of patients with severe ischemia and a complete follow-up (median 41 months, Follow-up Index 0.99). Rapid open surgical revascularization without preoperative thrombolysis can lead to good rates of limb salvage and bypass patency despite poor runoff.

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Conflict of Interest

The authors declare no conflict of interest.

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Tables

Table 1

Demographic data	
Number of patients, n (%)	51 (100%)
Age (years), median (range)	75 (46-97)
Male, n (%)	47 (92%)
Comorbidities, n (%)	
Coronary artery disease	22/51 (43%)
Previous vascular surgery	11/51 (22%)
Hypertension	40/51 (78%)
Diabetes	8/51 (16%)
Dyslipidemia	27/51 (53%)
Smoking	31/51 (61%)
GFR ≤60ml/min	5/51 (10%)
COPD	3/51 (6%)

Table 2

Parameter	Proportion	%
Rutherford classification of acute ischemia at presentation		
IIa	20/51	39
IIb	20/51	39
III	11/51	22
Existing contralateral PAA	31/51	61
Previous surgery	6/31	19
Intra-arterial thrombolysis		
Preoperative	2/51	4
Intraoperative	17/51	33
Type of surgery		
Primary amputation	4/51	8
Bypass / interposition graft	47/51	92
GSV	43/47	91
Omniflow	2/47	4
Omniflow with cephalic vein	1/47	2
PTFE with GSV	1/47	2
Approach		
Medial	44/47	94
Dorsal	3/47	6
Target vessel		
Below-knee popliteal artery	26/47	55
Anterior tibial artery	2/47	4
Tibioperoneal trunk	5/47	11
Posterior tibial artery	4/47	9
Peroneal artery	6/47	13
Combined	4/47	9

Figure and Table Legends

Table 1. Demographic data and comorbidities (Abbreviations: GFR = glomerular filtration rate, COPD = chronic obstructive pulmonary disease)

Table 2. Clinical presentation and surgical data (Abbreviations: GSV = great saphenous vein, PTFE = Polytetrafluoroethylene)

Figure 1: Distribution of patent crural vessel after revascularization.

Figure 2: Kaplan-Meier estimate of amputation-free survival including 95% confidence intervals (dotted lines).

Figure 3: Kaplan-Meier estimates of primary assisted and secondary patency rates.